

The Determinants of Urban Density - The Israeli Case

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Paper presented at the The 42nd Congress of the European Regional Science
Association, Dortmund, August 27th-31st

ABSTRACT

In the struggle against urban sprawl minimum requirements for urban density has become one of the promising tools in determining spatial planning policy, particularly in densely populated countries such as Israel. This study examines the variation in urban densities among 150 urban and rural localities in Israel. Two-way analysis of variances was employed in order to classify the localities into clusters based upon their urban density, size, location and spatial functionality. A regression model is then applied in order to examine the relationship between urban density and selected spatial variables. While most former classification studies use economic, social and demographic variables as a basis for their analysis, in the current study, the classification is based upon urban spatial structure and land uses.

The findings obtained in the classification analysis and the identification of variables that affect urban density the most, could equip planning agencies with a benchmark for urban density norms.

1. Introduction

Urban sprawl has become one of the major spatial phenomena of urban growth in the developed world. The high population growth in Europe and North America during the Post World War II years has accelerated urban sprawl that started at the end of the Industrial Revolution age in the Western countries and has continued until today (Hortshorn and Muller, 1992)

Planners and researches blame urban sprawl as the cause accounting for a major planning problems in the cities and for the negative effect in the social, economic and environmental perspectives (Masnavi, 2000). Among these are the lack of economic efficiency, air pollution resulting from the increase uses of private vehicles, weakness of the economic base of the city centres and irreversible damage to open spaces and nature landscape resources (Kasadra, 1985; Ewing, 1997; Burchhell et al., 1998, Downs, 1998)

This process is intensified by the increase in the level of motorization and the improvement in the means of transportation, the rise in the standard of living, the growing demands for low density housing, the lower level of urban taxation in the outskirts and escapees from the big city morbidity at the end of the Industrial Revolution age (Golledge and Stimson 1997).

According to Garreaue (1991) and following by Hartshorn and Muller (1992) the emergence of the edge cities is a later expression of urban sprawl. Based on the life cycle theory of metropolitan regions developed by Klassen et al. (1981) and Van Den Berg et al. (1982), the edge cities are a spatial phenomenon of the disurbanisation phase in the development of the metropolitan regions. Batty et al. (1999), sum up by pointing at three major problems characterising the spatial dynamics of urban growth: The decline of central cities or the core cities, the emergence of competitive edge cities supplying the urban function, previously served by the core cities, and the fast suburban process that occurs in any type of city.

It was after the World Congress on Sustainable Development held in Rio de Janeiro in 1992, that many states in the US decided to implement growth management policy in order to restrain the urban sprawl, followed by a public debate on this topic (Burchell et al., 1998). In Israel, efforts against the suburban process and urban sprawl have been accelerated to a great extent in the 1980's and the 1990's and become a major issue of concern by the planning agencies (Razin, 1998). Its implications on the urban

development emerge particularly as a consequence of Israel population growth, which is the highest in the developed world, depicted in its 2.5% annual average growth rate between the years 1970-1998. In addition are the limited reserves of land, available for urban future development, due to the limited physical size of the country. Therefore, uncontrolled urban sprawl and suburban phenomena together with the non-homogeneity in the population spatial distribution will have a crucial effect on the country's ability to maintain land reserves for future needs. This is conversely to other western countries where the population growth is very low (some of them show a negative population growth rate), or alternately, they comprise large amount of land reserves (Frenkel, 1996).

Throughout the years, many places have developed policies in order to limit the urban sprawl. Today the growth management policy is a comprehensive framework that encompasses a great variety of tools, some of which are old and others are new, and all of them have been adopted by the local level as well as the national level of many States in the US (Alterman 1997). In the struggle against uncontrolled and unregulated urban development, the implementation of a spatial planning policy has become a major strategy, in which the determination of a minimum requirement for urban density is one of the promising tools (Weitz, 2000). In Israel, this tool was first proposed by the Israel Master Plan "Israel 2020"¹ in the mid of the 1990s', as an instrument designed to control the conversion of open spaces into urban land. It was subsequently adopted by the National Outline Plan no. 35².

It is reasonable to assume that determining minimal requirements of urban density should vary spatially and be tailored to suit the different type of urban localities. Accordingly, this requires a preliminary analysis to test the significant differences between localities in their urban density and the composition of their land uses. This study examines the variation in urban density based on empirical data from 150 urban and rural localities in Israel.

The aim of this study is to address the decision makers with knowledge base that could be used as a basis for determining density norms as one of the tools that should be included in a comprehensive spatial planning policy in Israel. This was done by examining the Israeli urban pattern of various localities and the relations that exist between these structures and the urban density variable. The presented analysis suggests

classification process, in which the sample of localities is divided into several clusters, based upon their urban density, size, location and spatial functionality.

This study joins the rich tradition of research classification studies starting in the 1940s that ranked US cities according to industrial specialisation data (Harris, 1943), and was followed by many other studies (see Nelson, 1955; Hart, 1955; Jones and Forestall, 1963; Forestall, 1967; Berry and Smith, 1972; Keeler and Rogers, 1973; Noyelle and Stanback, 1983; Berry, 1996; Hill et al., 1998). The main reason for these classifications may have been a convenient way to summarise information or identify new hypotheses, as well as suggesting a general typology. Other reasons lead to developing prediction models using subgroups instead of the total population, or selecting analogues of comparative cases (Berry and Smith, 1972). Many of the earlier studies test the spatial organisation of US cities in the context of central place theory (Hill et al., 1998). Later on, in the 1970s, the classification studies shift more towards the goals of public policy, relying on measuring social outcomes.

Most of the studies mentioned above use economic, social and demographic variables as a basis for their classifications. Some of them are more spatially oriented, yet the analysis did not focus on the spatial urban structure and land uses. Thus, the contribution of this study lies in the selected variables used in the classification analysis. This study intends to examine the relation between urban density and the urban spatial structure of the settlements expressed by their size, functionality, and land uses. The resultant typology assisted in adopting minimal requirements for urban density norms at the national plans in Israel.

2. Population Density and Urban Development

In recent years many countries have shown great interest in the relation that exist between urban density and urban development. Increasing the intensity of land use and human activities in the region is one way of inducing a sustainable milieu (Williams, 2000). The terms ‘intensity’ and ‘density’ are interpreted as urban cramming, due to which concept the building, typical of many European countries after World War II, is characterised by very low urban density (20-30 dwellings per hectare). Insufficient attention is paid to the question of how we can plan an urban environment of distinction

to assure a better quality of life alongside a more intense use of space and buildings (Urban Task Force, 1999).

Urban density policy introduced in many European countries and also in several States in the US is trying to act and change the urban pattern, especially in metropolitan areas, by means of increasing urban density, augmenting the use of, and expanding existing buildings and sites (Davey, 1993; Alexander, 1993; Kaiser, et al., 1995)

The effect of the free market forces on the population spatial distribution and its negative implication on land supply have brought about the appearance of post-modern architecture movements in the US during the 1970s, calling to return to urban compact forms in order to restrain urban sprawl and suburban chaos. The concern generated by the sprawl toward the suburbs has established the New-urbanism movement in the 1980s aimed at redefining the American metropolis by reviving the more traditional planning methods (Fulton 1996; Schiffman 1999)

In order to regulate the expected growth, several States in the US have adapted spatial policy, in accordance with national goals, mainly in places where the region holding capacity has been adversely affected. The guidelines of these policies are: control the shape and the structure of urban forms, control the population dispersal, and prevent the suburban processes and the stochastic expansion of the cities. Control of the city growth process enables to achieve continuity in the urban pattern, centring in the built-up areas and avoidance of unnecessary damage to farmland, open spaces or nature and landscape resources. The control of the city growth encourages redevelopment of the city centres, denseness of the urban pattern in the centre and the outskirts, thus reducing the dependency of the residents on private transportation (De-grove 1989, 1992; Kaiser et al. 1995; Ingram, 1998)

In Europe, likewise, the growth pole policy that dominated the spatial development until the end of the 1980s and the beginning of the 1990s (Parr, 1999a; 1999b) has shifted towards a compact city approach. Large concentrations of residential areas and business activities are no longer located outside the central areas, but rather near and inside the big cities. The reason underlying the new strategic concept implemented in Western Europe, and to a large extent in the Netherlands, was to diminish negative damage to the environment and reduce traffic volume of private vehicles. The basic assumption was

that this could be achieved by supplying a stock of dwellings and jobs inside the cities through the intensification of the existing built-up areas (Breheny, 1992, Dieleman et al., 1999). However, Breheny (1992) claimed that the decision rendering the implementation of the compact city policy ignored the influence of urbanisation. As a consequence, this policy deprives the rural population in Britain following the concentration of the economic activity into intensified urbanised areas.

In general, two principal approaches in spatial planning are addressed: The first supports public intervention in the planning process on a basis of sustainable development principles. The second approach suggests that the planning process should be led by the free market forces that control the urban development, thereby excluding any public intervention (Johnson, 2001). On this background, the debate at the end of the 1980s, which focused on the concept of urban concentration versus dispersed development in space, has become a leading topic. There are some who support an aggressive policy in order to reduce the sprawl. Among them are Jenks et al. (1996), Ewing (1997), Downs (1998), and Hadly (2000) who blame the directed policy that has been led throughout the years. On the other hand, there are others who are opposed, claiming that sprawl is not a preventable phenomenon primarily stemming from changes in the international global economy and led by the market forces (Mills and Hamilton, 1989; Gordon and Richardson, 1997).

According to Mills and Hamilton (1989) the suburban phenomenon is not limited only to the period after World War II in the US, but a consistent phenomenon characterising all industrialised countries since the beginning of the twenty-century until today. They argue that the decline of the large cities mainly in the northern centre and north east America has occurred despite the absence of interracial tension, high taxation, low level of education and other features. The negative population growth rate and the restraint of migration from rural regions to the cities are the suggested conjectures. Thus the suburban process is a permanent and continuous phenomenon that only partially explains the process of the city decline. Therefore, determining directed policy in order to stop this phenomenon is unjustified and probably impossible.

Analysing the factors that cause urban sprawl can serve as a basis behind valued and practical debate on the implementation of this phenomenon and our operative capability to control it. Thus focusing on policy factors in the analysis presents those that believe

in the ability of the planners to control, manage, and restrain the sprawl. On the other hand, analysis that emphasises the global economy factor presents a liberal attitude in justifying the sprawl, and is opposed to the planning trial designated to stop and restrain this phenomenon.

In a free market economy, business entrepreneurship allocates land and capital to create properties within the private sector. Entrepreneurship is the engine that motivates the wheel of economic growth by creating land values. The developers gamble on their ability to supply market demands through urban developments. They will enjoy higher returns than the cost of the development, for which purpose they are willing to take risks and are ready to suffer financial failure in order to win the game (Kaiser et. al., 1995). On the other hand, in a high population growth situation, leaving the location choice and development timing only in the hands of the free market could cause market failures and the collapse of urban systems. It is thus worthwhile using growth management policy in regions where development and growth trends surpass regional capacity and the objectives of national plans. The aim of this policy is to regulate the expected growth according to national goals. This is achieved by maximising reconciliation between local planning and national targets and goals. It is related to the location, size, type, quality and cost of the suggested development. The development must accordingly consider values consistent with characteristics of the different types of neighbourhoods such as environmental preservation, prevention of urban sprawl, land allocation based on public considerations such as environmental quality, as well as identifying demand.

3. Framework of the Study

3.1 Methodology

This study intends to examine the differences in the urban densities, characterise settlements that differ in their size, location and spatial functionality, and the urban land use structure, by using data collected from a sample of 150 localities. The purpose of the analysis was to classify these localities into clusters in order to equip the Israeli planning agencies with a benchmark in which urban density norms will be conducted, as part of a spatial planning policy offered by the two national plans. The National Master Plan for Israel in the 21st century ("Israel 2020") that first had raised the public

debate over the efficiency of using the land resources and the National Outline Plan No 35 that followed (Mazor et. al., 1997; Asif and Shachar , 1999).

The importance of formulating spatial rules derives from the impact of the expected population growth in Israel on the reduction of land reserves, particularly in the demand areas (Frenkel, 1999). Its relevancy raised market trend preferences exhibited in low urban densities that caused uncontrolled waste of land resources, as is the situation in Israel.

3.2 Hypotheses

It is assumed that urban density play a significant role in determining the city's physical structure and the level of efficiency achieved by use of its land. According to Torrenes and Alberti (2000), urban density is measured by the ratio between the amount of an urban activity and the land area in which the activity is carried out. In most of the studies, the urban density variable is measured by the number of dwellings, the number of residents or the number of employees per unit of land (Razin and Rosentraub, 2000). The geographical units defined for the purpose of measuring the density indices varies from metropolitan areas to city or neighbourhood scale, and might influence the results and the conclusions that will derive from the study.

In relation to the results obtained from other studies (Mazor, 1993), it is expected that the high intensity of the built-up area increases with the size of the city and reflects the land market values that result in more efficient use of land, thereby affecting the population density.

One should be looking into the spatial functionality and geographical location of urban localities on a basis of a core – periphery axis. Urban density is expected to decrease with the distance from the centre. It is thus hypothesised that the distribution of land uses within different types of settlements varies according to their spatial function. Core cities are expected to allocate the highest percentage of their urban built-up area to general urban functions. These core cities function as employment and service centres not only for their population, but also for the entire metropolitan region. On the other hand, satellite cities located in the metropolitan region function rather as dormitory towns, where the percentage of the residential area is expected to be the highest. Towns located on the periphery are required to supply more general urban functions for their

population. Their residents cannot rely on receiving services and jobs from the metropolitan region, which are beyond an acceptable commuting distance. Thus it is expected to have a negative gradient of urban density from the core cities towards the periphery.

Another factor that is expected to have an effect on urban density is that of the urban landscape. It is assumed that topography reduces urban density because much land is wasted in settlements located in areas of steep topography, where the possibility of using that land is less feasible in comparison to the ability on flat areas.

Finally, it is hypothesised that the size of the city built-up area may negatively affect urban density. Cities where the built-up area extends on large areas are less efficient in using their reserved land, thus reducing the urban density and contributing to the urban sprawl process.

3.3 The Model

In order to classify the localities into clusters, a two-way analysis of variance (ANOVA) statistical model was conducted. The urban gross density is the dependent variable in the model, measured by the number of inhabitants per Km^2 of the total urban built-up area (including all types of urban land uses). Two independent variables were used in the model as a basis for categorising the localities into groups: the locality size and the locality location and spatial functionality. The null hypothesis of the model states that there are no differences between the urban density with respect to locality size or functionality; therefore, there is no statistical basis for this grouping. Significance variability in the dependent variable will reject the null hypothesis and accept the alternative hypothesis indicating that there are significance differences between clusters of localities.

The locality size was measured by the number of inhabitants, divided into four categories as obtained from the analysis:

1. Large city >100,000 inhabitants
2. Medium city - 25,001-100,000 inhabitants
3. Small city - 5,001-25,000 inhabitants
4. Small urban and rural locality - <5,000 inhabitants

In the second category the localities were divided into groups according to their function and location *vis-a-vis* the core - periphery axes. Since there was no prior notion regarding any preferred division, I accept the Israeli Central Bureau of Statistic's definition as a starting point with some additions:

1. Core cities in the metropolitan region Inner ring localities
1. Middle ring localities
2. Outer ring and the metropolitan outskirts localities
3. Peripheral localities

In the next phase a multiple regression model was employed in the empirical analysis, in order to examine the relationship between urban density and selected spatial variables. The relative contribution of each of the independent variables to the explanation of the urban density was also obtained from the model. In particular, I consider four explanatory spatial variables that may influence the urban density D_i . This suggests a model of the form:

$$D_i = f(S_i, F_i, T_i, BA_i) \quad (1)$$

Assuming that a linear function exists, we can write the specifications of equation 1 as following:

$$D_i = \mathbf{b}_0 + \mathbf{b}_1 S_i + \mathbf{b}_2 F_i + \mathbf{b}_3 T_i + \mathbf{b}_4 BA_i + \mathbf{e}_i \quad (2)$$

where:

D_i is the gross urban density of locality I (measured by the number of inhabitants per Km^2).

S_i refers to the size of locality i (measured as Ln of number of inhabitants).

F_i refers to the locality spatial functionality and location (a categorical variable: Core city=0, Peripheral city=4, see the above definition).

T_i indicates whether locality i located on flat land = 1, or in mountainous topography = 2 (a dummy variable).

BA_i Built-up area of locality i (measured in km^2).

β Parameters to be estimated.

ϵ_i Error term.

Finally, the composition of the various land uses, existing in the urban built-up area of the clusters of localities identified in the previous phases, were analysed.

3.4 Data Sources

The data gathered from a land use survey conducted by the Geography Department of the Israeli Central Bureau of Statistics. The land allocated to different uses in the built-up areas was measured using detailed urban maps. The final database included 150 localities (observations) distributed all over the country, most of them urban localities. Although they represent only 13% of the total number of settlements (see Table 1 below), 87.6% of the total population of Israel resides there. The representation of the urban population in the sample data is even higher – it accounts for 81.5% of the total urban settlements in Israel in which 96.5% of the urban population resides.

Table 1: Sample Population and its Representative Rate

Type of locality	Number of sample localities	Number of total localities	% of sample localities from total	% of population resides in sample localities from total
Total	150	1,161		
Urban localities ¹		173		96.5
Rural localities		988		2.4

Source: Central Bureau of Statistics.

1. According to the C.B.S' definition of urban localities (above 2,000 inhabitants).

On the other hand, the rural settlements, whose population accounts for less than 10% of Israel's total population, are not represented sufficiently in the sample. However, most of the future development in Israel is expected to be in urban localities, while the building pattern, typical of the rural settlements, is usually expressed in low-density, single-family houses. Therefore, despite the low representation of the rural settlements, it would not negatively affect the possibility of classifying the entire settlements into clusters.

4. Empirical results

4.1 Locality Clusters

The average gross urban density, characterising the two categories - the locality size and the locality location and spatial functionality, is presented in Table 2 and 3. As expected, the results obtained from the analysis indicate an increase in the urban density with the rise in the locality size. In general, there is also a reduction of the urban density with the remoteness from the centre to the periphery, except for the inner ring localities in the metropolitan regions

Testing the differences between each of the pairs of locality groups in both categories, by employing the T-test statistical model indicates that all differences are statistically significant, except for the difference between groups no. 4 and 5 in Table 3. However, this exception was taken into consideration after employing the two-way analysis of variance according to the two categories (see below).

Table 2: Average of gross urban density (inhabitants per Km²) by locality size

Locality size	N	Gross urban density
1. Large city <100,000 inhabitants	11	8,937
2. Medium city - 25,001-100,000 inhabitants	29	6,640
3. Small city - 5,001-25,000 inhabitants	29	3,249
4. Small locality - <5,000 inhabitants	20	2,021
Total	89	5,424

Table 3: Average of gross urban density (inhabitants per Km²) by locality location and spatial functionality

Locality spatial function and location	N	Gross urban density
1. Core city in the metropolitan region	4	6,676
2. Inner ring localities	11	9,218
3. Middle ring localities	15	4,808
4. Outer ring and the metro. outskirts localities	42	4,608
5. Peripheral localities	17	3,122
Total	89	5,424

The Arab localities in the sample containing 61 localities were excluded from the analysis. The reason for that emerges from the unregulated development of land uses of these localities³, since the development of their physical pattern did not result from a controlled planning. Rather, it was constrained by historical causes connected to the lack of statutory planning, their land ownership pattern and the social norms concerning land development accepted by the Arab society and expressed in a multi-generation

building pattern. Analysis of the variance between the Arab localities, relative to several combinations of the size or location variables, did not produce any significant statistical results. There was, therefore, no justification to ascribe them to any of the clusters of localities as was done for the Jewish localities that could serve as a benchmark in determining a density norm policy. However, it is hoped that in the long run, the Arab localities will have a regulated planning process. Hence, it is as appropriate to apply similar spatial policy to this sector, as it is for the Jewish sector.

Employing the two-way analysis of variance statistical model, with the combinations of the two mentioned categories of localities, was done in order to test the justification of defining typical clusters. The results obtained from the ANOVA statistical model show that there are statistically significant differences in the level of urban density between groups of localities with respect to their size, function and location. The average urban densities in each group of localities are presented in Table 4.

Table 4: Two-way analysis of variance (ANOVA), between groups of localities according to their urban density, size, location and spatial functionality (number of observations in parenthesis)

Locality size	Type of locality	Means of gross urban density (inhabitants per Km ²)
Large city >100,000 inhabitants (11)	Core city (4)	6,677
	Inner ring city (4)	13,867
	Middle ring city (2)	6,910
	Outskirts city (1)	8,293
	Peripheral city (0)	n.o.
Medium city - 25,001-100,000 inhabitants (24)	Core city (0)	n.o.
	Inner ring city (5)	10,327
	Middle ring city (3)	5,632
	Outskirts city (12)	4,801
	Peripheral city (4)	4,106
Small city - 5,001-25,000 inhabitants (34)	Core city (0)	n.o.
	Inner ring city (2)	3,460
	Middle ring city (7)	5,238
	Outskirts city (15)	3,035
	Peripheral city (10)	3,545
Small locality - <5,000 inhabitants (20)	Core city (0)	n.o.
	Inner ring localities (0)	n.o.
	Middle ring localities (3)	1,611
	Outskirts localities (14)	2,738
	Peripheral localities (3)	1,715

Two way ANOVA statistical results: locality size*locality type - F= 2.51; df=74, 7; Sig.= 0.023

n.o = This combinations of factors does not exists.

Total number of observations = 89.

Significant differences in the urban density parameters exist between types of localities, particularly in the two first size groups - large cities and medium cities. In the two other groups - small cities or small urban and rural localities, the differences are minimal; that is, the impact of the location and spatial functionality on urban density is significant among large or medium cities, but not so when the size of localities dropped to less than 25,000 inhabitants. The latter are influenced by the size factor with little relevance to their spatial location.

Based on these results, a selection of several clusters of localities was done. The decision regarding which combination localities should be included in a chosen cluster was based on the differences in the urban gross density parameter with given consideration also to the differences in the residential density variable. The final identification process suggests six principal groups of localities differing significantly in their urban physical pattern as presented in Table 5. The results obtained from the one-way analysis of variance point at the statistical and significant differences that exist for the two dependent variables that were tested (urban gross density and residential density). The first four clusters are a combination of the size, location and spatial functionality of the cities included in. On the other hand, clusters 5 and 6 relate only to the size variable.

In addition, the variability in the urban density parameters between pairs of the chosen clusters was examined by employing a t-test statistical model. In most cases the results indicate significant statistical differences between the pairs of clusters. Thus providing a legitimate basis for the final classification that could serve as benchmark in addressing minimum requirements of urban density norms in spatial planning policy. The exceptions are the differences in the gross urban density between the core cities (cluster 1) and the middle ring cities (cluster 3), or between the medium cities located in the outskirts or in the periphery (cluster 4) and the small cities (cluster 5). However, the differences in the residential densities characterising these clusters were found to be statistically significance. This emerges from the physical patterns of these clusters as will be discussed in section 4.3 below and justifies the preferred classification.

Table 5: One-way analysis of variance (ANOVA) between types of localities according to their density indices (inhabitants per Km²)¹

Cluster's localities	Urban gross density	Residential density ²
1. Core cities with more than 100,000 inhabitants (4)	6,676	13,032
2. Inner ring cities with more than 25,000 inhabitants (9)	11,900	17,234
3. Middle ring cities with more than 25,000 inhabitants (6)	6,502	10,585
4. Medium cities comprise 25,001-100,000 inhabitants, located in the outskirts of the metropolitan area and in the periphery (16)	4,630	9,848
5. Small cities comprise 5,001-25,000 inhabitants (34)	3,664	7,307
6. Small urban and rural localities with less than 5,000 inhabitants (20)	2,415	3,900
Total (89)	4,716	8,480

One-way ANOVA statistical results: Urban gross density - F= 26.83; df=83, 5; Sig.= 0.000

Residential density - F= 22.82; df=83, 5; Sig.= 0.000

1. Number of observations in parenthesis

2. The residential area includes the residential parcels and the attached neighbourhood infrastructure, such as public institutions, local business centre, local parks and open spaces and local roads.

In general, the findings in Table 5 show a gradual reduction in the population density of urban built-up areas, when moving from the metropolitan centres to the periphery, and with the reduction in the locality size. An opposite trend may be observed within the metropolitan regions. The population density of the core cities is significantly lower, particularly in comparison to the medium and large cities located in the inner ring. These results remind the behaviour of the population density distribution on a city scale, according to the exponential negative function, as first defined by Clark (1951) and later supported by others (McDonald, 1989, McDonald and Mcmillen, 1998; Wang and Zhou, 1999).

4.2 Regression analysis

In an attempt to explain the differences in the urban gross densities between localities, a multiple regression analysis was conducted. The analysis includes only those variables which turned out to be significant. The coefficients and t-values of the estimates are presented in table 6.

The coefficients of the two first variables indicate the significant impact of the locality size and the location and spatial functionality on the urban density, thus reconfirming the main hypothesis of the study. The results from the regression model reinforce the

justification for determining differential density norms within a spatial planning policy with given consideration to the difference in size and location of the cities. An adequate minimum requirement of urban density norms has to increase with the size of the city and decrease when moving from the centre towards the peripheral regions.

Table 6: Regression Results of the Determinants of Urban Gross Density

Variables	Coefficients	t-values
(constant)	-5652.8	-2.216*
Size (Ln of number of inhabitants in locality)	1783.2	7.815**
Functionality (categorical variable indicate the location and spatial functionality of locality)	-1369.9	-5.331**
Landscape topography of locality (dummy variable 1= locality located in located on flat land; 2= locality located in mountainous topography)	-1362.7	-2.247*
Total built-up area (Km ²)	-192.4	-5.391**

n=89

F=36.80; sig.=0.00; Adj. R² = 0.64

* Significant at 95% level (t>1.96).

** Significant at 99% level (t>2.30).

Apart from the aforementioned variables, there are two other explanatory variables that appear to have a significant negative effect on urban density; the landscape topography and the total built-up area. As expected, urban density decreases in areas of steep topography, and it is conceivable that this result is due to the waste of land, in comparison to the situation in flat areas. The coefficient shows that in a mountainous topography the density decreases by almost 1,400 inhabitants per Km². This could reflect a decrease of 10% in the urban gross density of large cities and up to 30% in small cities located in the periphery, and should be taken into consideration in a future spatial policy. The significant negative effect of the size of the built-up area on the urban density confirms our expectation; i.e., the inefficient use of urban land by cities that extend on a large built-up area, thus decreasing their urban density. The decrease of the urban density as measured by the regression coefficient is quite insignificant; for every increase of the built-up area by one km², the decrease in urban density is only by 200 inhabitants per km². This should definitely not be taken as a factor in any spatial normative policy, but rather it should encourage the implementation of more aggressive growth management policy particularly in such cities.

The F-values computed in the regression is statistically significant at the one percent level, and the level of explanations obtained, as depicted in the values of the adjusted R-squares, is relatively high – 64%.

4.3 Land Use Structure in Patterns of Settlements

The data collected in the survey includes also the distribution of land uses in the built-up area of the localities included in the sample. It was thus possible to analyse and classify the typical pattern of land uses in each of the six defined clusters as determined in the previous section. The Arab localities added to the analysis as the seventh cluster, as explained above. The results obtained from employing the one-way analysis of variance on the distribution of the land uses, according to the tested clusters of localities, was found to be statistically significant in all cases, as presented in Table 7. The result implies that a different type of land use pattern characterised these clusters.

The residential area (including the affiliated neighbourhood services) is the predominant land use in the urban built-up area as obtained from the distribution presented in Table 7. It accounts for 63% of the total built-up area on average. In the Jewish settlements (clusters 1-6) it accounts for half to 70% of the total built-up area. Its share is higher particularly among the inner ring cities (clusters 2) and to a lesser extent in the middle ring cities (cluster 3) than within the core cities (cluster 1) or in cities that are located in the outskirts of the metropolitan region or in the periphery (cluster 4). This result implies the high intensity of the residential areas in the ring cities inside the metropolitan region that typically function more as dormitory towns based of services given to them by the core cities, thus characterised by the highest level of urban density. The share of residential area of the total urban built-up area increases within the small urban and rural localities.

On the other hand, the distribution of land use in the Arab localities (cluster 7) indicates the greatest share of land allocated to residential purpose accounting for 83% of the total built-up area. This is a particularly salient point when compared to a rate of about 50% among clusters 4 and 5 of the Jewish localities which are compatible with cluster 7 in their location and size. This result attests to the less developed urban services among the Arab localities, as well as the difficulty in obtaining land for public facilities at the neighbourhood level in these localities.

Table 7: Distribution of Urban Land Use - % From the Urban Build-Up Area, ANOVA Between Patterns of Localities

Settlement's pattern	Land Use					
	Residential area	Mix land uses ¹	Industrial area	Public services ²	Open spaces ²	Special land use ^{2,3}
1. Core cities with more than 100,000 inhabitants	50.9	5.8	12.8	6.6	13.4	10.3
2. Inner ring cities with more than 25,000 inhabitants	70.5	3.0	11.3	2.4	1.5	10.1
3. Middle ring cities with more than 25,000 inhabitants	61.7	3.9	10.5	5.2	2.6	16.1
4. Medium cities comprise 25,001-100,000 inhabitants, located in the outskirts of the metro. area and in the periphery	48.0	3.6	12.7	5.2	12.1	18.3
5. Small cities comprise 5,001-25,000 inhabitants	50.1	2.1	11.8	4.1	19.9	11.0
6. Small urban and rural localities with less than 5,000 inhabitants	61.9	2.6	3.0		15.3	15.8
7. Arab localities	83.1	0.3				
Average	62.9	2.2				
F value	8.299	5.032	8.639	5.803	2.664	1.278
Significant	0.000	0.000	0.000	0.000	0.019	0.273

Number of observations with full data set of the distribution of land uses was 102.

1. Includes intensive land uses within the central business.

2. These include continuity land uses in the city level with an area not below 3 hectare each.

3. Includes land use like: Hotels, sport facilities, army camps, and cemeteries.

The intensity of the mix land uses, including those slated for commercial, business, and residential purposes (mainly in the locality centre), decreases with the remoteness from the core of the metropolitan region to its fringes, and with the reduction in city size (cluster 1-3). It is also related to the high dependency of the cities in the metropolitan region on the core city for supplying these services. In contrast, there are the Arab localities (cluster 7) where the percentage of the mix land uses of the total is the lowest in comparison to the other clusters. This finding reaffirms the state of the under-developed physical urban landscape of the Arab localities.

What is also interesting but not very surprising is the modest variation between the locality clusters, in the proportion of industrial land use of the total urban developed area. In most clusters, excluding the small urban and the rural localities, the percentage of industrial land use is similar, ranging from 10.5%-12.8%. This is probably the result of the tremendous effort made by most of the local authorities to develop local industrial areas, since it provides a significant source of income for their municipal fiscal budget. In light of this background, once again, the spatial inequality of the Arab localities is very clear. Only 0.8% of the total developed land is allocated to industrial uses, far below the rate in the Jewish locality clusters. This result indicates the severe lack of development of an economic infrastructure, forcing these localities to depend on employment outsourcing.

The allocation of land for urban public services indicates that the highest proportion of land of the total built-up area designated for these uses is, as would be expected, in the core cities (6.6%). These supply public services to the population residing in the entire metropolitan region. For this reason, this proportion decreases to less than 3% in the big cities on the inner ring of the metropolitan region, depending more than other clusters on the metropolitan services provided in the centre. In all the other clusters, excluding the urban and rural localities, the percentage of land used for public services is similar. This is due to the fact that most of the cities are self-contained in supplying these basic urban services. Once again, emerging from this finding is the under-development of the Arab localities (cluster 7). The percentage of the land allocated to public services in these localities decreases to less than one percent, half of the rate in comparison to the small urban and rural Jewish localities.

The findings also indicate that apart from the core cities, most other cities located in Israel's metropolitan regions, provide few open spaces or urban parks. The proportion of land allocated to this purpose increases considerably in cities located in the outskirts of the metropolitan region and in the periphery, or in the small cities and small urban and rural localities. The land use of the open spaces in these localities is not large, despite the low building densities there. However, some of these towns are located on sloping land, thus resulting in a relatively large amount of wasted land allocated as open space.

6. Summary and Conclusions

In the next two decades Israel's population is expected to grow by 50%, a very rapid growth rate compared to any other Western country. By the year 2020 Israel is expected to reach a population of close to 9 million, compared to 6.5 million in 2001. This tremendous growth will create a high demand for land reserves designated for urban development. It will encourage the conversion of farm land to urban land uses, especially in the demand areas. The density of the urban built-up area directly influences the land reserves needed to provide for the expected population growth. It is therefore worthwhile outlining a spatial urban density policy aimed at creating efficient land use, particularly in a country where land reserves are limited.

The trend towards spatial development in Israel in recent years indicates an ongoing increase in urban sprawl. This will be particularly noticeable in small towns and rural settlements located on the outskirts of the metropolitan regions. The fast growth of population has not necessarily resulted in an increase in the urban density of these localities. On the contrary, the tendency is expressed in the continued urban development of low density, single family housing in small and scattered settlement patterns, causing inefficient use and wasted land reserves. An assessment done in the framework of "Israel 2020", shows that the rural settlements in Israel account for 40% of the settlements' built-up area, but only 7% of the population resides there (Frenkel, 1996). This finding evinces one of the main, and most difficult, spatial problems that spatial planning policy will have to address in the near future.

This study presents an empirical analysis of the land use patterns in different types of localities, based on a sample of 150 localities, embracing 87.5% of the population of Israel. Classification of the localities into typical clusters, according to their urban density as a function of their size, location and spatial functionality, is included in the analysis.

The results obtained from the statistical analysis indicate the significant spatial differences that exist between clusters of settlements. The importance of this classification lies in its ability to serve as a benchmark for promoting minimal requirements for urban density norms within a spatial policy, pertaining to the future supply of land reserves in Israel. These findings are the result obtained from analysing

the trends in the development of the urban patterns in Israel in the last decades, basically encouraging urban sprawl; therefore it could not present necessarily desirable spatial goals. Nevertheless, it should assist the decision-makers in the planning agencies in determining spatial planning policy, by addressing reference frame on the principal variables that should be taken into consideration. In addition, it would equip them with a benchmark on the existence of relative differences in the urban density, which are affected by the significant explanatory variables identified in this study.

The success of such spatial and growth management policy depends on its ability to create consensus concerning the policy tools to be used for intensifying urban density. This policy must be based on reorganising authority and deregulation in order to deal with planning problems in future decades. Developers and planning authorities will have to be given clear instructions on urban design and planning relative to urban density and the quality of life. These instructions must consider the differences in the social values and their implications on local circumstances. It will therefore be necessary to propose different urban density norms that will obligate the local level when approving statutory plans for developing additional land reserves.

Notes

- ¹ “Israel 2020” is a national master plan for Israel in the 21st century that was prepared between 1991-1996. This master plan focuses mainly on the organisation of national spatial development and presents a future “map” of the country. The project was carried out at the Haifa Technion, with joint ministerial funding.
- ² NOP/35 is a statutory Outline Plan, commissioned by the National Committee for Planning and Building in 1997, based on the platform of “Israel 2020”. The plan, in its final stages of preparation, includes a physical plan as well as policy recommendations on the future development of the country.
- ³ Includes localities with Arab populations, displaying almost the same spatial behaviour norms. In some of the Jewish localities, especially in the big cities, there is a minority Arab population, yet it does not have a direct effect on the physical urban pattern, which is quite different from that of the Arab localities.

References

- Alexander, E. (1993) Density Measures: A Review and Analysis, *Journal of Architecture and Planning Research*, 10 (3), pp.181-202.
- Alterman, A. (1997) The Challenge of Farmland Preservation, Lessons from a Six-Nation Comparison, *Journal of the American Planning Association*, 63 (2), pp. 220-243.
- Asif, S., Shachar, A. (1999) *LAND – National Comprehensive Outline Scheme and Principles for Building and Development Document – NOS/35*, Vol. A, Principals of the Plan and Policy Means, Jerusalem.
- Batty, M., Xie, Y., Zhanli, S. (1999) *The Dynamics of Urban Sprawl*, Working Paper Series No. 15, London: Centre for Advanced Spatial Analysis, University College London, www.casa.ucl.ac.uk/sprawl.pdf.
- Berry, B. (1996) Technology-sensitive urban Typology, *Urban Geography*, 17, pp. 674-689.
- Berry, B. and Smith, K. (1972) *City classification handbook*, New York: Wiley-Interscience.
- Breheny, M.J. (1992) The Contradiction of the Compact City: A Review, in M.J. Breheny, (Ed.) *Sustainable Development and Urban Form*, London: Pion.

Burchell, R.W., Shad, N.A., Listokin, D., Phillips, H., Seskin, S., Davis, J.S., Moore, T., Helton, D., Gall, M. (1998) Transit Cooperative Research Program (TCRP), chapters 6-8 in Report 39: *The Costs of Sprawl-Revisited*, pp. 83-125 Washington, D.C: Transportation Research Board, National Research Council.

Clark, C. (1951) Urban Population Densities, *J. Roy. Statist. Soc.*, A114, pp. 490-496.

Davey, P. (1993) Sustainable Suburbia, *The Architectural Review*, 193 (11), 4-5.

De Grove, J.M. (1989) Growth Management and Governance, in D. Brower, D. Godschalk, D. Porter (Eds.) *Understanding Growth Management- Critical Issues and a Research Agenda*, pp. 22-42 Washington D.C.: Urban Land Institute.

De Grove, J.M. (1992) *The New Frontier for Land Policy, Planning and Growth Management in the States*, Cambridge: Lincoln Institute of Land Policy.

Dieleman, F.M. and Dijst, M.J. (1999) Planning the Compact City; the Randstad Holland Experience, *European Planning Studies*, 7 (5), pp. 605-623.

Downs, A. (1998) How America's Cities Are Growing: The Big Picture, *Brooking Review*, 16 (4), pp. 8-12.

Ewing, R. (1997) Is Los Angeles-style Sprawl Desirable?, *Journal of American Planning Association*, 63, pp. 107-126.

Forestell, R. (1967) Economic Classification of Places Over 10,000, 1960-1963, in *The Municipal Yearbook 1967*, pp. 30-65. Chicago: International City Managers Association.

Frenkel, A. (1996) *Land Demand Model for the Year 2020*. Report No.19, "Israel 2020" Master Plan for Israel in the 21st Century – Stage B, Haifa: Technion (Hebrew).

Frenkel, A. (1999) The Impact of the Population Fast-Growing Trends in Israel On it's Spatial Future Development, Paper presented at the XIII AESOP Congress, Bergen, Norway, 7-11 July.

Fulton, W. (1996) *The New Urbanism*, Cambridge, MA: Lincoln Institute of Land Policy.

Garreau, J. (1991) *Edge City: Life on the New Frontier*, New York: Doubleday.

Golledge, R.G., Stimson, R.J. (1997) Urban Patterns and Trends, chp. 4 in *Spatial Behavior- A Geographic Perspective*, pp. 111-154, New York: The Guilford Press.

Hadly, C.C. (2000) Urban Sprawl: Indicators, Causes , and Solutions, Prepared for the Bloomington Environmental Commission,
<http://www.city.bloomington.in.us/planning/boardcomm/ec/reports/sprawl.html.p>,
 Accessed 12/5/01.

Harris, C. (1943) A Functional Classification of Cities in the United States, *Geographical Review*, 33, pp. 86-99.

- Hart, J. (1955) Functions and Occupational Structures of Cities in the American south, *Annals of the Association of American Geographers*, 45, pp. 269-286.
- Hill, E.W., Brennan, J.F. and Wolman, H.L. (1998) What is a Central City in the United States? Applying a Statistical Technique for Developing Taxonomies, *Urban Studies*, 35 (11), pp. 1935-1969.
- Hartshorn, T.A., Muller, P.O. (1992) The Suburban Downtown and Urban Economic Development Today, in E.S. Mills and J.F. McDonald (Eds.), *Sources of Metropolitan Growth*, 147-160, New Jersey: Center for Urban Policy Research.
- Ingram, G.K. (1998) Patterns of Metropolitan Development: What Have We Learned?, *Urban Studies*, 35 (7), pp.1019-1035.
- Jenks, M., Burton, E., and Williams K. (eds.) (1996) *The compact City, A Sustainable Urban Form?*, London: E & Fn SPON.
- Jones, V. and Forestall, R. (1963) Economic and Social Classification of Metropolitan Areas, in: *The Municipal Yearbook 1963*, pp. 31-44. Chicago: International City Managers Association.
- Johnson, M.P. (2001) Environmental Impacts of Urban Sprawl: A Survey of the Literature and Proposed Research Agenda, *Environment and Planning A*, 33, pp. 717-735.
- Klaasen, L.H., Molle, W.T.N., Paelinck, J.H.P. (1981) *The Dynamics of Urban Development*, Aldershot: Gower.
- Kaiser, E.J., Godschalk, D.R., and Chapin, F.S. (1995) *Urban Land Use Planning*, Urbana: University of Illinois Press.
- Keeler, E. and Rodgers, W. (1973) *A Classification of Large American Urban Areas*, Santa Monica, CA: The Rand Corporation.
- McDonald, J.F., McMillen, D.P. (1998) Population Density in Suburban Chicago: A Bid-rent Approach, *Urban Studies*, 35 (7), pp. 1119-1130.
- Masnavi, M. (2000) The New Millennium and the New Urban Paradigm: The Compact City in Practice, in: K. Williams, E, Burton, M. Jenks (Eds.), *Achieving Sustainable Urban Form*, pp. 64-73 London: E & FN Spon.,
- Mazor, A. (1993a) Land Resources in Spatial Planning. in A. Mazor, et al., "Israel 2020" *Master Plan for Israel in the 21st Century - Stage A*, pp. 125-212, Haifa: Technion, (Hebrew).
- Mazor, A. and Sofer, M. (1997) *'The Future Map': Plan for the Organization of the National Spatial*, Israel Master Plan for the in the 21st Century Thousands, Haifa: Technion, (Hebrew).
- Nelson, H. (1955) A Service Classification of American Cities, *Economic Geography*, 31 (3), pp. 189-210.

Noyelle, T.J. and Stanback, T.M. (1983) *The Economic Transformation of American Cities*, Totowa, NJ: Rowan & Allanheld.

Razin, E. (1998) Policies to Control Urban Sprawl: Planning Regulations or Changes in the 'Rules of the Game'?, *Urban Studies*, 35 (2), pp. 321-341.

Razin, E., Rosentraub, M. (2000) Are Fragmentation and Sprawl Interlinked?: North American Evidence, *Urban Affairs Review*, 35 (6), pp. 821-836.

Schiffman, I. (1999) *Alternative Techniques for Managing Growth*, 2nd edition, Berkeley: University of California, Institute of Governmental Studies Press.

Torrens, P.M., Alberti, M. (2000) *Measuring Sprawl*, Working Paper Series, No. 27, London: Centre for Advanced Spatial Analysis, University College, presented to the Association of Collegiate Schools of Planning Conference, Atlanta, GA, www.casa.ucl.ac.uk.

Van Den Berg, L., Drewett, R., Klaassen, L.H., Rossi, A. Vijverberg, C.H.T. (1982) *A Study of Growth and Decline*, Urban Europe, Vol.1, New York: Pergamon Press.

Urban Task Force (1999) *Towards an Urban Renaissance*, Final Report of the Urban Task Force Chaired by Lord Rogers, London: Spon.

Wang, F., Zhou, Y. (1999) Modeling Urban Population Densities in Beijing 1982-90 Suburbanisation and its Causes, *Urban Studies*, 36 (2), pp. 271-287.

Weitz, J. (2000) State Programs that Bust Sprawl and Measures that Can Be Used in Diagnosing Sprawl, 2000 APA National Planning Conference, www.asu.edu/caed/proceedings00/WEITZ/weitz.htm, Accessed 12/05/01.

Williams, K. (2000) Does Intensifying Cities Make Them More Sustainable?, in: K. Williams, E. Burton, and E. Jenks (Eds.) *Sustainable Urban Form*, pp. 30-45, London: E & FN Spon.